Aging of Polyurethane Foams: XPS and NEXAFS

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INTRODUCTION

Many systems are difficult to study due to their heterogeneity in space - some examples are living systems, emulsions, and foams. Spectromicroscopy allows one to examine regions of the samples on size scales on the order of their heterogeneity. This allows one to see spectral characteristics of the pure components of the sample. Other techniques of sample preparation and study typically yield averaged or potentially compromised data.

We are studying the aging behavior of polyurethane foams. These foams have three different spatial regions - cells filled with gas (~300-700 microns diameter) surrounded by walls (~1 micron and thinner), supported by a structure of wall intersections ("struts" - 10-80 microns across). These foams are structured on a scale small enough that normal methods do not probe the differentiation of composition across the network. There are many high valued systems that use polyurethane foams either as structural elements or as packing/shock adsorbing systems. Understanding the degradation mechanisms will lead to improved materials and improved monitoring of present materials.

We expect that there are several possible degradation processes - those that proceed without the involvement of external chemical agents (migration of polymer components, breaking of the polymer bonds) and external decay (oxidation, hydrolysis, etc.). We are looking for spectral features characteristic of polymer aging - and in particular, we are looking for spatially differentiated characteristics of aging.

In our studies on 7.3.1.2 we have been examining epoxy embedded samples that have been sectioned to 100-200 nm thickness. Our goal has been to follow degradation by XPS and NEXAFS on the micron scale - thus, does the wall regions, and the outside layer of the struts, show different composition than the internal regions of the polymer?

As part of this effort we are developing sample handling and analysis methodology. We have shown that transmission NEXAFS can be done on 7.3.1.2 using a photodiode detector built into the sample puck (figure 1). We can make chemical state maps using NEXAFS, and have extracted carbon edge spectra (figure 2). Work will be ongoing to systematically study aged foams in a variety of aging regimes and atmospheres.

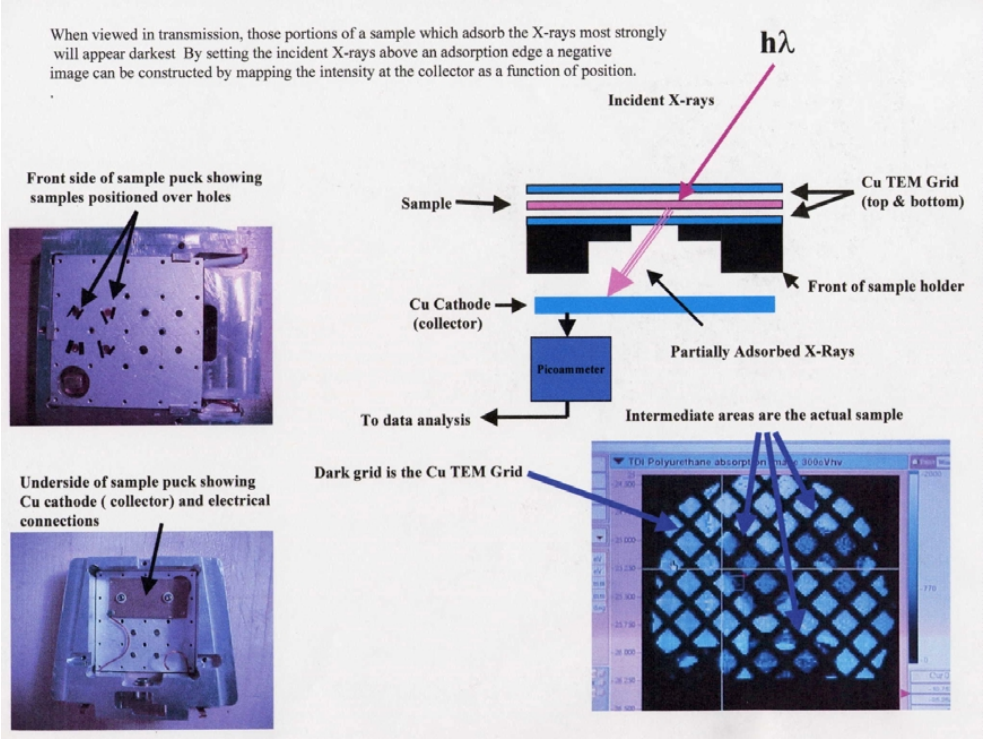

Figure 1. Modifications of the 7.3.1.2 sample puck to allow transmission NEXAFS of insulating samples

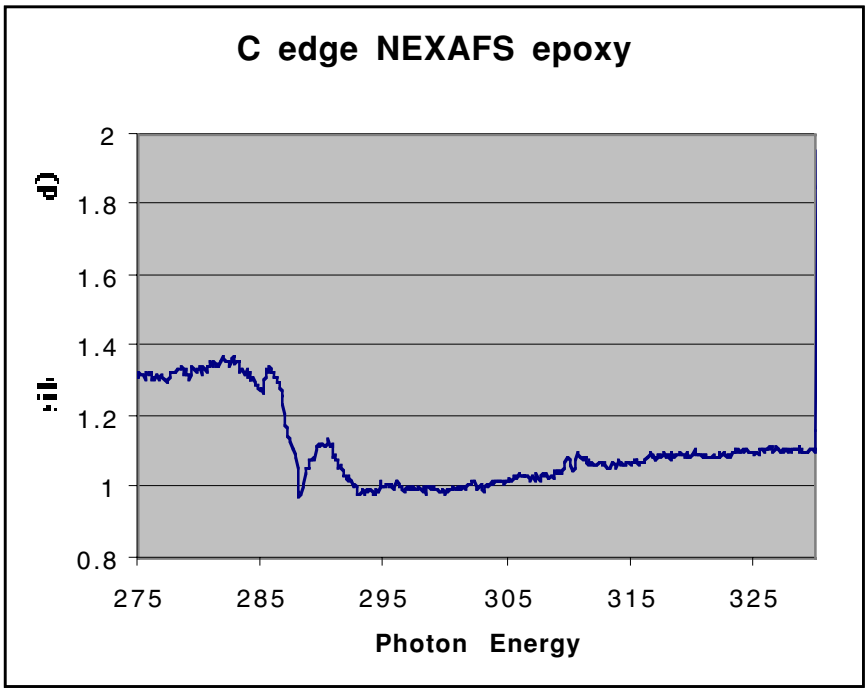

Figure 2. Absorption C edge NEXAFS of sample.

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